

phsl Lec 8

Acid-Base Balance

- **Acid–Base balance** precise regulation of free (unbound) hydrogen ion concentration $[H^+]$ in the body fluids.
- **Acids:** hydrogen-containing substances that dissociate in solution to liberate free H^+
- A **strong acid** has a greater tendency to dissociate in solution
- The extent of dissociation for a given acid is always constant and is expressed as its **dissociation constant (K)**
 - Like H_2O dissociation into 1 H^+ (no matter what the amount is it always give 1 H^+)
- **Base** is a substance that can combine with a free H^+ and thus remove it from solution.
- A **strong base** is one that can bind H^+ more readily

The pH Concept

- The **pH** is a measurement without units and represents the free Hydrogen ion concentration $[H^+]$ within a given solution.
- pH represents the inverse logarithmic scale of hydrogen ion activity
$$pH = \log_{10} 1/[H^+] = -\log_{10} [H^+]$$
- The fact that the pH scale is inverse & logarithmic (log 10) means that for each reduction of one in pH, there is a 10-fold increase in the hydrogen ion concn.
- The pH of pure H_2O is 7.0, which is considered chemically neutral.
- pH less than 7.0 contain a higher $[H^+]$ acidic.
- pH value greater than 7.0 have a lower $[H^+]$ basic, or alkaline.
- Normal pH range in body is 7.35 - 7.45.
- An arterial pH of **less** than 6.8 or **greater** than 8.0 is **not compatible** with life.
- **Survival range (6.8 -8.0)**

pH: physiological importance

- ionization status of most molecules
- Every protein & enzyme has an optimal pH. The majority of the body's enzyme systems work optimally at physiological pH.
- The importance of Acid-Base regulation stems from the critical importance of the hydrogen ion (H^+) concentration on the operation of many cellular enzymes and function of vital organs.
- Consequences of fluctuations in pH:
 - Changes in excitability of nerve and muscle cells
 - Marked influence on enzyme activity
 - Changes influence K^+ levels in body
- In general, body produces more acids than bases.
- Sources of H^+ in the body:
 - Volatile acid (in respiratory)
 - CO_2
 - Nonvolatile acids (in kidney)
 - sulfuric acid & phosphoric acid)
 - (lactic acid)

pH: Defense against Changes

(Know the duration of each)

Lines of Defense Against pH Changes:

1. Chemical buffers:
 - Function almost immediately (seconds to minutes).
2. Respiratory mechanisms:
 - Acts at a moderate speed (minutes to hours)
3. Renal mechanisms:
 - Hours to days.

1. Chemical Buffers: First line of defense against pH change.

<div>▲ TABLE 15-6</div> Chemical Buffers and Their Primary Roles	
Buffer System	Major Functions
Carbonic Acid: Bicarbonate Buffer System	Primary ECF buffer against non-carbonic acid changes
Phosphate Buffer System	Important urinary buffer; also buffers ICF

2. Respiratory Mechanism

Regulates pH by controlling rate of CO₂ removal

Acidosis: hyperventilation

Hyperventilation for any reason can cause: alkalosis

3. Renal Mechanism

Controls pH of body fluids by adjusting

- H⁺ excretion (in PCT)
- HCO₃⁻ excretion/ reabsorption (in DCT+ collecting tubule : intercalated cells)
- Production of new HCO₃⁻
- Ammonia secretion

Summary of acidosis and alkalosis

<div>▲ TABLE 15-8</div> Summary of Renal Responses to Acidosis and Alkalosis						
Acid-Base Abnormality	H ⁺ Secretion	H ⁺ Excretion	HCO ₃ ⁻ Reabsorption and Addition of New HCO ₃ ⁻ to Plasma	HCO ₃ ⁻ Excretion	pH of Urine	Compensatory Change in Plasma pH
Acidosis	↑	↑	↑	Normal (zero; all filtered is reabsorbed)	Acidic	Alkalinization toward normal
Alkalosis	↓	↓	↓	↑	Alkaline	Acidification toward normal

Other Urinary Buffers

- the **minimal urine pH** is about **4.5**(after that kidney cant excrete H⁺ -can't compensate-)
- **Phosphate is mostly ICF buffer and also the most abundant renal tubular buffer**
- Normal levels:
 - HCO₃ = 21 – 28 mEq/L
 - PCO₂ = 35 – 45 mmHg

$$\text{pH} \propto \frac{[\text{HCO}_3^-] \text{ controlled by kidney function}}{[\text{CO}_2] \text{ controlled by respiratory function}}$$

Acid-Base Imbalances (no clinical Q's will be in final)